Gear Drive Mechanism for Continuous Variable Valve Timing of IC Engines

S. Nakkeeran

Abstract--- *Continuous variable valve actuating (CVVA) technology provides high potential in achieving high performance, low fuel consumption and pollutant reduction. To get full benefits from (CVVT) various types of mechanisms have been proposed and designed. Some of these mechanisms are in production and have shown significant benefits in improving engine performance. In this investigation a newly designed gear drive mechanism that controls the intake valve opening (IVO) and closing (IVC) angles is studied. The control scheme is based on maximizing the engine brake power (P) and specific fuel consumption (BSFC) at any engine speed by continuously varying the phase between the cam shaft angle and the crank shaft angle. A single-cylinder engine is simulated by the "LOTUS" software to find out the optimum phase angle for maximum power and minimum fuel consumption at a given engine speed. The mechanism is a planetary gear drive designed for precise and continuous control. This mechanism has a simple design and operation conditions which can change the phase angle without limitation.*

Keywords--- *Gear Drive Mechanism, Variable Valve, VVT.*

I. INTRODUCTION

In internal combustion engines, variable valve timing (VVT), also known as variable valve actuation (VVA), is a generalized term used to describe any mechanism or method that can alter the shape or timing of a valve lift event within an internal Combustion engine. The (VVT) system allows the lift, duration or timing (in various combinations) of the intake and/or exhaust valves to be changed while the engine is in operation, which have a significant impact on engine performance and emissions. In a standard engine, the valve events are fixed, so performance at different loads and speeds is always a compromise between drivability (power and torque), fuel economy and emissions. An engine equipped with a variable valve actuation system is freed from this constraint, allowing performance to be improved over the engine operating range . Some types of variable valve control systems optimize power and torque by varying valve opening times and/or duration. Some of these valve control systems optimize performance at low and mid-range engine speeds. Others focus on enhancing only high-rpm power. Other systems provide both of these benefits by controlling valve timing and lift. There are many ways in which this can be achieved, ranging from mechanical devices to hydraulic, pneumatic and camless systems . Hydraulic system suffer from many problems including viscosity change of the hydraulic medium due to the temperature change, the liquid tends to act like a solid at high speed, and hydraulic systems must be carefully controlled, which require the use of powerful computers and very precise sensors. Pneumatic system utilizing pneumatics to drive the engine valves would in all probability not be feasible because of their complexity and the very large amount of energy required for compressing the air. Camless system (or, free valve engine) uses electromagnetic, hydraulic, or pneumatic actuators to open the poppet valves instead.

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Received: 04 Apr 2019 | Revised: 03 May 2019 | Accepted: 04 June 2019

Common problems include high power consumption, accuracy at high speed, temperature sensitivity, weight and packaging issues, high noise, high cost, and unsafe operation in case of electrical problems. Multiair system (or Uniair) is an electro-hydraulic variable valve actuation technology controlling air intake (without a throttle valve) in petrol or diesel engines. The system allows optimum intake valve opening schedules, which gives full control over valve lift and timing.

II. CONTINUOUS VARIABLE VALVE TIMING (CVVT)

Independent control of the intake and exhaust valves in an internal combustion engine . For any engine load criteria, the timing of intake and exhaust can be independently programmed and the engine's performance could be optimized under all conditions. However, if valve timing could be controlled independent of crankshaft rotation, then a near infinite number of valve timing scenarios could be accommodated which would dramatically improve fuel economy and emission levels of an automobile. These systems are used in several automobiles with gasoline engine like Toyota, Nissan, Honda, and others. In 2010, Mitsubishi developed and started mass production of its 4N13 1.8 L DOHC I4 world's first passenger car diesel engine that features a variable valve timing system. One of the high effective mechanisms proposed for controlling variable valve timing is planetary gear mechanism. The planetary gearbox arrangement is an engineering design that offers many advantages. One advantage is its unique combination of both compactness and outstanding power transmission efficiencies. A typical efficiency loss in a planetary gearbox arrangement is only 3% per stage. This type of efficiency ensures that a high proportion of the energy being input is transmitted through the gearbox, rather than being wasted on mechanical losses inside the gearbox. Another advantage of the planetary gearbox arrangement is load distribution. Because the load being transmitted is shared between multiple planets, torque capability is greatly increased. The more planets in the system the greater load ability and the higher the torque density. The planetary gearbox arrangement also creates greater stability due to the even distribution of mass and increased rotational stiffness. Hence, in this work we will present a new design of planetary gear drive mechanism for Continuous variable valve timing IC engine

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A rotation of the stepper motor shaft leads to the rotation of the ring gear resulting in additional rotation for the planetary gears and the external sun gear and the camshaft. This additional rotation results in phase change between the crank shaft and the cam shaft.

III. MECHANISM INSTALLATION

The mechanism is operated by planetary gear train to continuously and precisely change the phase angle between camshaft and crank shaft. The internal ring gear has an external worm tooth so it can acts like a worm wheel. It trains with the worm. The mechanism is operated by planetary gear train to continuously and precisely change the phase angle between camshaft and gear. The four identically planetary gears are meshing with the ring gear and the sun gear and they are carried by the two arms. The mechanism is installed to the internal combustion engine as follows: the mechanism is carried by bearing in such way that the camshaft and the sun gear shaft are coaxial and then shafts are connected by the

IV. THE ADVANTAGES OF THE MECHANISM

The main advantages of the above mechanism over other mechanisms can be summarized as follows: The change in the phase angle is constrained to the motion of the stepper motor, which can be controlled with accuracy up to 1.8 degrees for each step with zero overshoot. This value will be smaller for the camshaft depending on the gear teeth numbers. The worm gear, which is connected to the stepper motor and meshing with ring gear, offers a self-locking mechanism for ring gear. That will guarantee a constant speed ratio between the camshaft and crank shaft for specific phase angle, which is necessary for good engine operation. In this mechanism there is no limitation for phase angle changing value, except the limitation imposed by the engine’s performance envelop.

Cam Phasing Optimization—Maximizing Power Output

In this work, the optimum values for intake and exhaust valve timing have been calculated to maximize brake power. These values were used to calculate and compromise the brake power and fuel consumption for different engine’s speeds and compression ratios. For the purpose of analyzing the engine characteristics the dimensions were considered with Lotus Engineering Software. The Lotus Engine Simulation and analysis program is an in-house code developed by LOTUS ENGINEERING Company since the late 1980’s. Validation of global per. In this work, the optimum values for intake and exhaust valve timing have been calculated to maximize brake power. These values were used to calculate and compromise the brake power and fuel consumption for different engine’s speeds and compression ratios.

V. CONCLUSION

A planetary gear drive mechanism is designed and implemented to optimize the performance of a four stroke single-cylinder engine. The mechanism precisely and continuously changes the phase angle between the cam shaft and crank shaft angles. The effect of optimizing the phase angle at a given speed on the brake power isappreciable. The increase of the brake power ranges between 21% and 35% depending on the engine speed and compression ratio as indicated in Table 3. This increase is large at low engine speed and drops as the engine speed increases.

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